HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Hatchery Program:	Tulalip Bay Chum
Species or Hatchery Stock:	Tulalip Bay Chum Salmon
Agency/Operator:	The Tulalip Tribes
Watershed and Region:	WRIA 7 (Snohomish), Puget Sound
Date Submitted:	March 2, 2004
Date Last Updated:	March 2, 2004

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of hatchery or program. Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip Chum

1.2) Species and population (or stock) under propagation, and ESA status.

Chum salmon (*Oncorhynchus keta),* Tulalip chum

1.3) Responsible organization and individuals

Indicate lead contact and on-site operations staff lead.

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Agency or Tribe: The Tulalip Tribes
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Name (and title): Mike Crewson, Fishery Enhancement Biologist
Agency or Tribe: Tulalip Tribes
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Other agencies, Tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program:

1.4) Funding source, staffing level, and annual hatchery program operational costs.

The Bureau of Indian Affairs. The Tulalip Tribes.

Staffing level: Four, full-time Tulalip Tribal employees, and numerous seasonal workers: one for eight months, one for four months, and from one to twelve temporary workers during spawning, egg shocking and picking, fish transfers, and tagging operations.

Operational costs are approximately $300,000 annually for the entire Tulalip Hatchery program.

Location(s) of hatchery and associated facilities.

Tulalip Creek- WRIA 07.0001, RMPC Code- 3F10308 070001 R.
Tulalip Salmon Hatchery- WRIA 07.0001, RMPC Code- 3F10308 070001 H.
Battle Creek- WRIA 07.0005.

Tulalip Tribes Bernie Kai-Kai Gobin Salmon Hatchery:
10610 Waterworks Road
Tulalip, WA 98271

Located at the juncture of the east and west Forks of Tulalip Creek and just above the point at which Tulalip Creek feeds into Tony's Marsh, river kilometer 2.0.

Battle (Mission) Creek rearing pond and spawning station:

Near to:
7615 Totem Beach Rd.
Tulalip, WA 98271

Located about 200 meters upstream from Tulalip Bay.

WRIA 7, stream number 0005, stream kilometer 0.2.

1.5) Type of program.

Isolated Harvest.

1.6) Purpose (Goal) of program.

The purpose of this program is to provide chum salmon for harvest by Tulalip Tribal members in a terminal area fishery. Production from this program is also available for harvest by the non-Indian commercial and sport fisheries and contributes to other directed and incidental harvest of chum salmon in fisheries in British Columbia, and Puget Sound preterminal areas.

1.7) Justification for the program.

The Tulalip chum stock is classified as a secondary management unit in all areas, except 8D, where the fishery is managed to target Tulalip chum that are surplus to hatchery escapement needs. All Tulalip chum carry a unique genetic mark, that was initially bred for in particular broodstock, enabling hatchery fish to be identifiable in terminal area fisheries and on natural spawning grounds. Stillaguamish and Snohomish natural chum are primary management units.

1.9) List of program "Performance Standards".

1. Provide hatchery chum for terminal area harvest in a manner that maintains overall harvest-related impacts to listed Chinook and other protected salmon populations below guidelines adopted in the co-managers' Puget Sound Chinook Salmon Harvest Management Plan.

2. Provide for harvest of hatchery-produced chum salmon in the terminal area in a manner that assures that natural escapement to the Stillaguamish and Snohomish chum salmon management units will meet or exceed the co-managers natural escapement goals for these units.

3. Release of juvenile program fish to accomplish standards 1 and 2 and monitor releases to document potential ecological interactions with ESA-listed Chinook salmon juveniles in estuarine and nearshore marine habitats.

Goal (Section 1.7-1.8)	**Performance Standard** (Section 1.9)	**Performance Indicator** (Section 1.10)
Produce chum salmon to meet harvest needs	Hatchery chum return will contribute to Area 8A mixed hatchery and natural commercial salmon fisheries and provide opportunity in Area 8D for sport fisheries after escapement needs have been assured.	On average, the estimated survival rate for the hatchery production will remain above .005 to provide: ● for the recruitment of at least 20,000 adult chum to Puget Sound , and ● for sufficient fish passing through Area 8A to provide at least 4,000 fish for the Tulalip hatchery chum escapement.
	Harvest will be directed at Tulalip hatchery chum in a manner such that it will not unduly impact listed wild salmon populations when considered in conjunction with all other harvest-related impacts.	▪ Annual fisheries plans will project exploitation rates below the Co-managers' guidelines for all Puget Sound Chinook management units. ▪ Post-season assessments of exploitation rates on Stillaguamish and Snohomish Chinook will remain below the co-managers' guidelines.

Goal (Section 1.7-1.8)	**Performance Standard** (Section 1.9)	**Performance Indicator** (Section 1.10)
	Harvest directed at Tulalip hatchery chum will not unduly impact naturally-produced chum salmon populations from the Stillaguamish and Snohomish River systems.	▪ Annual chum spawning escapements will exceed co-managers' minimum escapement goals for both management units. ▪ Post-season assessments of exploitation rates on Stillaguamish and Snohomish chum will remain below co-managers' guidelines (50% maximum harvest rate on each management unit).
Hatchery program returns will provide sufficient broodstock needed to maintain production goals.	At least 4,000 adult chum will escape to hatchery return ponds in Tulalip Bay each year.	At least 4,000 adult chum will escape to hatchery return ponds in Tulalip Bay each year.
Genetic and ecological impacts to natural populations will be limited to acceptable levels.	Hatchery production will not contribute significantly to naturally-spawning populations.	The proportion of Tulalip-origin spawners in natural spawning areas will remain below co-managers' guidelines.
	Broodstock collection will be carried out with little or no risk to natural populations.	See above for details.
	Release practices have minimal or no impact on natural production.	The level of interaction among hatchery-origin fall chum released into Tulalip Bay with out-migrating natural-origin salmon smolts will be evaluated. We will test the hypothesis that the time of the peak abundance of Tulalip fall chum salmon and naturally-produced salmon in Tulalip Bay do not differ significantly.

1.10) List of program "Performance Indicators", designated by "benefits" and "risks."

Please see the performance standards in Section 1.9 above. Note, annual accomplishment of research, monitoring, and evaluation projects listed throughout this HGMP, and in performance standards and indicators, is contingent on availability of funding. As of 2004, most HGMP monitoring projects have been accomplished primarily through acquiring Hatchery Reform and

BIA self-governance funds specifically dedicated for hatchery reform and rehabilitation.

1.11) Expected size of program.

1.11.1) Proposed annual broodstock collection level (maximum number of adult fish).

Most Tulalip Bay chum salmon broodstock are collected at the Battle Creek spawning station located approximately 200 meters upstream from the mouth of Battle Creek in Tulalip Bay. A few chum returns also return to the lower Tulalip Creek pond. These returns are also taken for broodstock, if needed. Our goal is to take 8.8 million eggs from these two stations. No adult chum are collected from natural populations.

1.11.2) Proposed annual fish release levels (maximum number) by life stage and location.

Life Stage	Release Location	Annual Release Level
Fingerling	Tulalip Bay	8.0 million

1.12) Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.

See Attachment 1. Survival estimates are based on Puget Sound run reconstruction with age proportions derived from scale-age analyses.

1.13) Date program started (years in operation), or is expected to start.

This program was started in the fall of 1976. A Memorandum of Agreement (May 20, 1981) between the Tulalip Tribes and the Washington State Department of Fisheries outlines the timelines and magnitude of intended chum and other salmon production at the newly-constructed Tulalip Hatchery (currently renamed as the Bernie Kai Kai Gobin Tulalip Salmon Hatchery), which has been functional since that time.

1.14) Expected duration of program.

This is an ongoing production program.

1.15) Watersheds targeted by program.

Tulalip Bay (within WRIA 7). This program is designed so that the entire return will be harvested in a terminal area fishery so that no hatchery returns will intentionally spawn naturally.

1.16) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

N/A. The reason alternative actions to having this program do not apply, is because the reason that this program was initially created was to address numerous goals that were not being addressed prior to its existence. The intent of the initiation of the Tulalip enhancement program, hatchery construction, and MOU agreement referenced in part 1.3 above, was to establish a Tulalip enhancement program, through cooperative efforts with the Washington State Department of Fish and Wildlife, for programming salmon enhancement for the Tribe's Usual and Accustomed Area, which was and is intended to fit into the context of a more comprehensive salmon management and enhancement approach for Puget Sound. The Tulalip Tribes and the State recognize(d) the need for such a plan and agree(d) to cooperatively work toward its development and refinement. The goals for this program were and still are to develop and improve long-term salmon management and enhancement programs by protecting and enhancing native salmon runs and increasing salmon production in the Stilliguamish-Snohomish management unit without adversely affecting native salmon runs, in accordance with established treaty/non-treaty allocation requirements.

SECTION 2. PROGRAM EFFECTS ON ESA-LISTED SALMONID POPULATIONS.

2.1) List all ESA permits or authorizations in hand for the hatchery program.

HGMP's are being developed to provide the basis for an incidental take permit under an Endangered Species Act Section 4(d) rule.

2.2) Provide descriptions, status, and projected take actions and levels for ESA-listed natural populations in the target area.

2.2.1) Description of ESA-listed salmonid population(s) affected by the program.

None.

- Identify the ESA-listed population(s) that will be directly affected by the program.

None

- Identify the ESA-listed population(s) that may be incidentally affected by the program.

Juvenile estuarine and nearshore residency of listed Puget Sound Chinook salmon may overlap with juveniles released by this program. Potential competitive effects are unknown at this time. Studies of juvenile salmonid utilization of estuarine and nearshore marine habitats, conducted by NOAA Fisheries and the Tulalip Tribes, are currently underway in the Snohomish estuary that will provide better information on the timing and spatial distribution of local listed populations and program fish so that we can assess the potential extent to which overlap may occur upon release.

2.2.2) <u>Status of ESA-listed salmonid population(s) affected by the program.</u>

- **Describe the status of the listed natural population(s) relative to "critical" and "viable" population thresholds.**

Currently, listed Chinook salmon populations from the Stillaguamish and Snohomish basins are above critical thresholds. Complete delineation of populations and determination of viable population thresholds has not yet been completed.

- **Provide the most recent 12 year (e.g. 1988-1999) estimates of annual production.**

- **Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed fish in the target area, and provide estimated annual levels of take, including how, where, and when the takes may occur, the risk potential for their occurrence, and the likely effects of the take**.

None. Juvenile estuarine and nearshore residency of listed Puget Sound Chinook salmon may overlap with juvenile chum released by this program. Potential competitive effects are unknown at this time. Studies of juvenile salmonid utilization of estuarine and nearshore marine habitats, conducted by NOAA Fisheries and the Tulalip Tribes, are currently underway in the Snohomish estuary that will provide better information on the timing and spatial distribution of local listed populations and program fish so that we can assess the potential extent to which any overlap may occur.

- **Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish**.

None.

Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

None. The extent of possible adverse competitive effects of hatchery juveniles on listed populations of Puget Sound Chinook has not been quantified at this time, but is thought to be very low. Program fish may provide an important food source for listed juvenile Chinook, other salmonids and fish species.

- **Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.**

N/A.

SECTION 3. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

3.1) Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. *Hood Canal Summer Chum Conservation Initiative*) or other regionally accepted policies (e.g. the NPPC *Annual Production Review* Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.

Not applicable.

3.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

The Puget Sound Salmon Management Plan (PSSMP 1985) sets out the legal framework under which co-management of hatchery programs occurs. Programs at the Bernie Kai-Kai Gobin Hatchery are included in the Stillagaumish/Snohomish Equilibrium Brood Document, which is currently in draft form only. Annual production levels are agreed to by the co-managers and are described in the Future Brood Planning Document. Hatchery escapement goals and terminal area harvest management plans are described in the annual co-manager's status report entitled, "*Puget Sound Salmon Management Forecasts and Management Recommendations for the Stilliguamish-Snohomish Region*", which is produced approximately in early-July each year. The basic agreements between WDFW and the Tulalip Tribes concerning the operation of the Bernie Kai-Kai Gobin Hatchery were set up in a memorandum of understanding dated May 29, 1981.

3.3) Relationship to harvest objectives.

Results from electrophoretic analysis of tissue samples collected from the chum fisheries in Area 8A and 8D are being used to estimate the weekly contribution of Tulalip hatchery chum to these fisheries. This is possible because, from brood years 1990 through 1993, allelic frequencies were altered at two loci by appropriate selection of spawners, and are now currently expressed in all subsequent progeny used for broodstock in this program. Although the appropriate statistical analysis techniques have not yet been finally determined at this time, preliminary analysis has indicated that the weekly contribution of Tulalip hatchery chum to the Area 8A fishery (a mixed natural/hatchery area) ranged from 29 to 49 percent over a six-week management period in 1994 and from 27 to 92 percent in 1995. Results for 1996, 1997, and 1998 showed a similar range of contributions to the 8A fishery. In Area 8D (the hatchery terminal area), preliminary results have shown that hatchery contribution rates exceeded 90% for statistical weeks 47 and after. For statistical weeks 45 and 46, results were variable, depending upon the year examined. See Rawson (1997; Attachment 2) for more information on these studies.

3.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years (1988-99), if available.

Chum-directed fisheries in Area 8A are managed based upon the status of natural stocks from the Stillaguamish and Snohomish Rivers, but receive a substantial contribution from Tulalip hatchery production. In Area 8D, fisheries are managed to target Tulalip hatchery chum surplus to hatchery broodstock needs. Catch in the net fishery is recorded on fish tickets. Recreational fishery harvest of chum salmon is minimal. Recent year terminal area chum harvests (treaty and non-treaty combined) are depicted in the following table.

Harvest levels and rates for program-origin fish for the last fifteen years (1988-2002).

Source: NWIFC Web TFT database.

Year	Area	Chum Total	Year	Area	Chum Total
1988	8A	104,039	1996	8A	12,855
1988	8D	36,090	1996	8D	29,612
1989	8A	44,667	1997	8A	1,059
1989	8D	12,502	1997	8D	3,524
1990	8A	50,715	1998	8A	13,656
1990	8D	6,916	1998	8D	67,592
1991	8A	49,990	1999	8A	20,051
1991	8D	8,304	1999	8D	5,238
1992	8A	55,556	2000	8A	4,305
1992	8D	9,754	2000	8D	8,937
1993	8A	82,844	2001	8A	19,670
1993	8D	15,283	2001	8D	156,096
1994	8A	79,692	2002	8A	101,644
1994	8D	29,880	2002	8D	41,685
1995	8A	20,184			
1995	8D	11,305		**Grand Total**	**1,105,199**

Harvest rates on Tulalip fall chum are managed to allow for sufficient escapement to reach the spawning facility for egg take needs (approximately 4,000 adult chum at current program levels). In most years, Tulalip chum spawning escapement needs are easily met, although the goal was not achieved in 1999. We will continue to sample fisheries for electrophoretic allozyme analysis, as funding allows, to evaluate the success of our management at achieving our objectives. See Rawson (1997); Attachment 2, for further information.

Fisheries directed at Tulalip hatchery chum have minimal or no impact on listed Chinook populations, because of timing differences and because the hatchery chum-directed fishery occurs in the limited area of Area 8D. Area 8A fisheries, which are directed at natural-origin chum, but which can receive a substantial contribution of hatchery-origin fish, have a very low impact on listed Chinook populations. The incidental harvest of Chinook salmon in Area 8A and 8D fisheries is quantified annually during each season's planning process, and expected Chinook harvests are included in overall modeling of impacts on Chinook stocks (see the Tulalip fall Chinook HGMP for further information).

3.4) Relationship to habitat protection and recovery strategies.

Major factors affecting natural production and habitat management plans to facilitate Chinook salmon recovery are under development by work groups in the Stillaguamish and Snohomish watersheds. Initial recommendations for the Snohomish basin are described in the *Initial Snohomish River Basin Chinook Salmon Conservation /Recovery Technical Work Plan (October 6, 1999).* The Co-managers recently submitted a plan for fisheries to be conducted between May 1, 2004, and April 30, 2009, for consideration by NOAAF. The *Co-managers' Puget Sound Chinook Harvest Management Plan* (February 21, 2003) lists harvest management objectives for each Puget Sound Chinook management unit. All operations of the Bernie Kai-Kai Gobin Hatchery are consistent with the above plans.

3.5) Ecological interactions.

Predators, such as river otters, mergansers, cormorants, staghorn sculpin, cutthroat trout, and dolly varden trout, are sometimes seen preying on juvenile program fish before and after being released into Tulalip Bay.

Hatchery fish can interact with listed fish species through competition and predation (Fresh 1997). Program fish can negatively impact listed fish populations through reduced growth, survival, and abundance. Several methods have been developed to assess potential negative ecological interactions and risks associated with hatchery programs (Pearsons and Hopley 1999; Ham and Pearsons 2001). The degree to which fish interact depends upon life-history characteristics which include: 1) size and morphology, 2) behavior, 3) habitat use and 4) movements (Flagg et al. 2000). Important considerations associated with hatchery practices include the type of species reared, fish size at time of release, number of fish released, and location(s) of program releases.

Interaction potential between hatchery- and natural-origin fish can certainly depend on habitat structure and system productivity. For example, habitat structure can influence predator-prey encounter rates (visibility), the amount of preferred spawning habitat, and fish susceptibility to flushing flows. System productivity determines the degree to which fish populations may be food-limited, and thus negatively impacted by density-dependent effects. The type and degree of risk associated with releases of program fish typically involve complex mechanisms. Actual identification and magnitude of causal mechanisms negatively impacting listed fish is not always definitive due to confounding factors such as human-induced environmental changes, indirect pathway effects, and the diversity of environments that salmon occupy throughout their life-cycle (Li et al. 1987; Fausch 1988; Fresh 1997; Flagg et al. 2000).

Given these complex mechanisms and site-specific considerations, it is not surprising that for most hatchery programs, including Tulalip hatchery chum salmon, the extent of possible adverse ecological effects of hatchery releases on listed fish populations has not been explicitly documented or quantified. However, because chum fry originating from this program are reared in freshwater devoid of any listed fish and are released directly into marine waters at a small size (370 fish per pound or approximately 1.2 grams per fish), there are no competition or predation interactions with listed fish in the freshwater environment and there are likely no predation interactions that are adverse to listed fish in the freshwater or marine environment. For these same reasons, adverse competitive effects on listed fish in the marine environment are believed to be very low or non-existent. Program fish may serve as a source of forage for listed fish.

Program chum are being released from 15 April through 1 May annually when listed Chinook salmon juveniles are known to be out-migrating from the Snohomish and Stillaguamish River systems and are present in the estuary and nearshore marine waters. Smolt trapping data Out-migration studies have been conducted since 2000 in the Stillaguamish River by the Stillaguamish Tribe (Griffith et al. 2001, Griffith et al. 2003, Griffith et al. 2004), since 2000 in the Skykomish River, and since 2001 in the Snoqualmie River by the Tulalip Tribes (Nelson and Kelder 2001, 2002a, 2002b, 2002c, 2003a, 2003b), and additional fyke netting and beach seining has been conducted in the Snohomish River estuary and nearshore marine areas by the Tulalip tribes and NOAA Fisheries since 2001. These studies are providing better information on the relative juvenile out-migrant timing and size of local listed and hatchery populations of Chinook and chum salmon, so that we can assess the extent to which any overlap between these species might occur after hatchery fish are released.

Chinook salmon juveniles and chum fry migrate and feed on epibenthic invertebrates in nearshore areas. While program chum and zero-age Chinook salmon juveniles may be of a similar size (50-60 mm fork length; 1 gram/fish body weight), the potential for spatial overlap and competition remains unknown at this time. Removal of the hatchery chum release site from the Snohomish estuary where emigrating Chinook salmon juveniles are most densely concentrated and release of program chum at a size, age, and stage of development that is conducive to their dispersal directly into pelagic rather than nearshore marine areas; act synergistically to reduce the potential for adverse ecological interactions between listed Chinook and program chum juveniles.

However, due to the timing overlap of release of program chum and known out-migration timing of listed Chinook salmon juveniles from the Snohomish River, the potential for resource competitive effects exist and are being investigated (see Section 12; Research).

The tendency for adult Tulalip chum to stray into natural spawning areas has been studied using genetic marking (Rawson 1997, Attachment 2). Tulalip chum were not found in any of the natural spawning areas, except for Quilceda Creek, sampled throughout the Snohomish and Stillaguamish systems. Natural chum spawning populations have been sampled in these areas during 2000 through 2002 as a follow-up to the earlier work, and genetic analysis of the recent samples is expected in 2003 or 2004. Based upon the currently available information, it is unlikely that Tulalip hatchery chum are present in any natural spawning areas utilized by listed Chinook salmon.

SECTION 4. WATER SOURCE

4.1) Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile, and natural limitations to production attributable to the water source.

Tulalip Bay chum salmon will be incubated on pathogen-free well water, with east fork Tulalip Creek water used only if there is a loss of well water due to power or pump failure. The fry, once ponded, will be reared on waters from the east and west fork of Tulalip Creek. When transferred to Battle Creek pond, they will be reared on Battle Creek surface water until they are released into Tulalip Bay.

4.2) Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

Water withdrawal and use has not and will not not affect listed natural fish, which are not present in Battle or Tulalip Creeks.

SECTION 5. FACILITIES

5.1) Broodstock collection facilities (or methods).

Broodstock will be collected at the spawning station at Battle Creek (WRIA 07.0005), and at times at the lower Tulalip Creek pond, (WRIA 07.0001).

The fertilized Tulalip Bay chum and milt will be taken at the spawning location(s), and then transported to the Bernie Kai-Kai Gobin Hatchery. Chum eggs will then be fertilized and placed in eying troughs, supplied by pathogen-free well water, where they will be incubated to the eyed stage. They will then be shocked, mortalitied will be removed, and the healthy eyed eggs will be placed on screens in outdoor raceways supplied by well water and east fork Tulalip Creek surface water through hatching, emergence, and early rearing at the hatchery.

5.2) Fish transportation equipment (description of pen, tank truck, or container used).

Green, unfertilized chum eggs will be transported from the Battle Creek spawning station to the Bernie Kai-Kai Gobin Hatchery (a distance of approximately one mile), in covered, three-gallon buckets. The buckets will be stored in a one-half-depth bath of creek water until transported to the hatchery, and are insulated from cold, if necessary during transport. Milt will be transported in sealed, oxygenated, plastic bags placed in a cooler above ice.

5.3) Broodstock holding and spawning facilities.

The majority of the Tulalip Bay chum broodstock has typically been observed to move into the spawning station in ripened condition, ready for spawning. Those that need to be held for ripening are placed in one of two holding pens, one for males, and the other for females. Adult chum held in these pens will be examined for ripeness every other day and spawned as they ripen.

5.4) **Incubation facilities**.

Tulalip Bay chum eggs will be incubated in eying boxes (modified Adkins boxes) in an incubation building specialized and reserved only for chum salmon at the Bernie Kai-Kai Gobin Hatchery. The eying boxes will be supplied with an inflow rate of approximately 4.5 gallons of water per minute.

Once eyed, the chum eggs will be shocked, mortalities will be removed, and the healthy, eyed eggs will be placed on screens placed within outdoor raceways to hatch. Upon hatching, chum alevins move through the screens to the artificial substrate in the bottom of the raceways, where they will absorb their yolk sacs and emerge into the water column and begin feeding.

The entire chum inventory will be ponded in 12 raceways that are 70 feet long by 6 feet wide by 0.75 feet deep. Each of these shallow raceways has a working volume of about 300 cubic feet.

5.5) Rearing facilities.

Once the chum absorb their yolk sacs and emerge into the water column for their first feeding, the hatching substrate will be removed and the fry will be introduced to a floating starter salmon mash. Once the fry are feeding well, they will be transferred to larger asphalt ponds at the Bernie Kai-Kai Gobin Hatchery. These ponds ("B and C") have a working volume of about 12,500 cubic feet. They will be held in these asphalt ponds until they attain a size of approximately 700 fish per pound (> 0.5 gram per fish), and then transferred to the Battle Creek pond, a large, earthen reservoir, for final rearing and release.

Once transferred to the Battle Creek pond, chum fry will be fed until they reach a size of approximately 450 fish per pound (approximately one gram per fish). At this size, their volitional release will be initiated by removing the screens at the pond outlet. During their volitional egression, feeding will be continued, and their mean weight will increase to approximately 375 fish per pound (approximately 1.2 grams per fish). At that time, the pond water level will be lowered by removing stop logs at the pond outlet creating a semi-volitional egression over several remaining days until the remaining fry in the pond have exited into the lower reach of Battle Creek, approximately several hundred meters above the mouth at Tulalip Bay. The Working volume of Battle Creek Pond is an estimated 250,000 cubic feet.

5.6) Acclimation/release facilities.

Battle Creek pond is the acclimation, final rearing, and release facility for Tulalip Bay chum. It is an earthen pond that gives the chum a very natural environment prior to release. The characteristics of this pond closely mimic natural rearing conditions, including overhead cover, earthen substrate, natural feed supplementation, in-column structure, natural inflow, natural camouflage coloration/pond coloration, and presence of natural predators. Program fish develop natural morphology and behavior, including more natural body coloration, predator avoidance and natural feeding behaviors, by adapting to these natural environmental conditions, which minimizes the influence of the artificial culture environment and is thought to increase their post-release survival. This oval-shaped pond is approximately 150 feet wide by 220 feet long, and its' depth varies from the shallow-sloped shore to approximately 15 feet deep in the center portion of the pond. It is formed by a dam and screened outlet structure at its downstream end.

5.7) Describe operational difficulties or disasters that led to significant fish mortality.

None.

5.8) Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

No listed fish will be directly or indirectly affected by this program. However,

1. The handling of the broodstock, spawning, and egg fertilization and incubation will be supervised by properly-trained hatchery personnel.

2. The well and hatchery water supply systems will be equipped with low-water alarm systems and back-up water supplies.

3. The hatchery will continue to be staffed by well-trained personnel who are on duty 24 hours per day, seven days per week.

SECTION 6. BROODSTOCK ORIGIN AND IDENTITY

Describe the origin and identity of broodstock used in the program, its ESA-listing status, annual collection goals, and relationship to wild fish of the same species/population.

6.1) Source.

The Tulalip Bay chum stock was derived from chum originally supplied to the Tribes by the United States Fish and Wildlife services facility on Walcott Slough in Hood Canal. In brood years 1990 through 1993, broodstock chosen for this program were selected for allelic frequencies at two loci that are unique for this stock, by examining their muscle tissue using electrophoresis, and all progeny have since been detectable and can be identified uniquely as Tulalip Bay chum. The stability of this mark will continue to be examined by collecting 100 emergent fry for analysis at the WDFW genetics laboratory as necessary to verify its reliability for stock identification.

6.2) Supporting information.
See HGMP for Walcott Slough and Associated Hatchery.

6.2.1) History.

After the first four years of eggs were supplied from the USFWS Walcott Slough facility, all broodstocking for this program has subsequently been done at the Battle Creek and Tulalip Creek spawning stations. Once the spawning station was constructed at Battle Creek in 1982, this became the major source of eggs for the program, with the lower Tulalip Creek station being a secondary broodstock collection and spawning location.

6.2.2) Annual size.

The USFWS supplied the tribes with 500,000 eggs each year for the first four years of this program. The cuurent green egg take goal is 8.8 million, with a release goal of 8.0 million fry annually into Tulalip Bay.

6.2.3) Past and proposed level of natural fish in broodstock.

No naturally spawning fish have been or will be used in this program.

6.2.4) Genetic or ecological differences.

Allelic frequencies at two loci are unique for this stock, detectable by allozyme electrophoresis of their muscle tissue.

6.2.5) Reasons for choosing.

This stock was chosen because it had very similar run timing (less than a ten-day difference in run timing from the natural chum runs in the rivers of this area), and because it is a stock with early spawning characteristics upon freshwater entry, originating in a short, lowland stream, which was thought to be a good fit for the short, lowland streams feeding into Tulalip Bay.

6.3) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices.

Only broodstock with the unique genetic mark have been selected for broodstock, and regular monitoring for this mark in resultant progeny, in fisheries, and in natural spawning areas ensures that no genetic introgression has occurred or will occur in the hatchery or in natural spawning areas.

SECTION 7. BROODSTOCK COLLECTION

See Section 5 above.

7.1) Life-history stage to be collected (adults, eggs, or juveniles).

See Section 5 above.

7.2) Collection or sampling design.

See section 5 above.

7.3) Identity.

See section 6 above.

7.4) Proposed number to be collected:

4,400 adult chum.

7.4.1) Program goal (assuming 1:1 sex ratio for adults):

8.8 million green eggs.

7.4.2) Broodstock collection levels for the last twelve years (e.g. 1988-99), or for most recent years available

Brood Year	Females Spawned	Males Spawned	Total Number of Broodstock Spawned
1998	2,571	837	3,408
1999	N/A	N/A	1,057
2000	1,705	799	2,504
2001	N/A	N/A	4,875
2002	N/A	N/A	4,367

7.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs.

All hatchery-origin fish that will be collected in surplus of broodstock needs will be distribute to Tulalip Tribal members for use as food.

7.6) Fish transportation and holding methods.

Surplus fish and usable carcasses will be transported by truck to Tribal members.

7.7) Describe fish health maintenance and sanitation procedures applied.

1. All spawning (as well as incubation and rearing) facilities will be cleaned at the end of each day. In the case of egg buckets, they will be cleaned and dried after each use.

2. Each year, Northwest Indian Fisheries Commission (NWIFC) fish pathologists will screen a representative number of adults returning to Tribal hatcheries for infectious fish pathogens that may be vertically-transmitted from parents to progeny. The exact number of fish to be tested from each stock is specified in the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State. The NWIFC pathologists work with hatchery crews to prevent or minimize pre-spawning mortality of broodfish to maximize egg fertilization and survival.

7.8) Disposition of carcasses.

Any carcasses that are suitable for food will be distributed to Tribal members. The remainder will be buried.

7.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program.

N/A. No listed fish are involved in this program. The risk of fish disease amplification will be minimized by following sanitation, fish health maintenance, and pathogen monitoring guidelines as described in the Salmonid Disease Control Policy of the Fisheries Co-manager's of Washington State (NWIFC and WDFW 1998).

SECTION 8. MATING

Describe fish mating procedures that will be used, including those applied to meet performance indicators identified previously.

8.1) Selection method.

Adult chum will be selected randomly over the entire return.

8.2) Males.

Milt from ripe fish will be placed in sealable, oxygenated plastic bags.

8.3) Fertilization.

Equal sex ratios will be used. Gametes will be pooled in lots of approximately 5.

8.4) Cryopreserved gametes.

N/A.

8.5) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

N/A. No listed fish are involved in this program. Random mate selection, equal sex ratios used during spawning, and the risk of fish disease amplification will be minimized by following sanitation, fish health maintenance, and pathogen monitoring guidelines as described in the Salmonid Disease Control Policy of the Fisheries Co-Manager's of Washington State (NWIFC and WDFW 1998) during mating.

SECTION 9. INCUBATION AND REARING

9.1) Incubation:

9.1.1) Number of eggs taken and survival rates to eye-up and/or ponding.

See section 5 above. Exact counts of eyed egg mortality or of swim-up fry numbers are not available. Hatchery inventory monitoring methods are currently under revision.

9.1.2) Cause for, and disposition of surplus egg takes.

Surplus eggs will be collected for sale as food, but are not fertilized or sold live for spawning purposes.

9.1.3) Loading densities applied during incubation.

The loading density in the modified Adkins eying boxes will be approximately 140,000 eggs per box, maximum loading density. The loading densities of eggs on hatching screens in the outdoor raceways will be 2,000 eggs per square foot.

9.1.4) Incubation conditions.

Fish and alevins will be incubated on 8.3 °C (47 °F) well water, except during extended power outages when east fork Tulalip Creek water will be used. Both water sources will be at or near oxygen saturation upon entry into the Adkins boxes and outdoor raceways, and will be discharged at above 90% of oxygen saturation.

9.1.5) Ponding.

Fry will volitionally emerge from raceway substrates when they have absorbed their yolk sacs and begin to initiate feeding behavior on their own. Thus, they will not actually be force-ponded as the term is usually applied.

9.1.6) Fish health maintenance and monitoring.

The eggs will be treated in the Adkins boxes prophylactically with a 1,667 ppm formalin drip treatment for 15 minutes, three times per week, to control growth of opportunistic *Saprolegnia* sp. fungus. When the eggs are eyed, they will be removed from the Adkins Boxes, shocked, and all dead eggs will be removed prior to placing the healthy eyed eggs onto the screens in the outdoor raceways. Once they have hatched, the screens will be removed from the raceways. Any additional dead eggs on the screens will be removed at that time. Also after the fry emerge, the artificial substrate will be removed from the raceways along with any dead eggs or alevins.

9.1.7) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation.

N/A. No listed fish are involved in this program. Volitional hatching and emergence are practiced and substrate is provided to mimic natural conditions. The risk of fish disease amplification will be minimized by removing mortalities at three different time periods as previously described in 9.16 above. This program follows sanitation, fish health maintenance, and pathogen monitoring guidelines as described in the Salmonid Disease Control Policy of the Fisheries Co-manager's of Washington State (NWIFC and WDFW 1998) during mating. Only healthy eggs free of regulated pathogens (there is no history of any in this program) will be cultured.

9.2) Rearing:

9.2.1) Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years (1988-99), or for years dependable data are available..

Approximately 80 percent overall survival will be expected from green egg to release.

9.2.2) Density and loading criteria (goals and actual levels).

Chum fry will be reared at densities under 0.5 pounds of fish per cubic foot of rearing space. Also see egg incubation loading densities described in Section 9.1.3 above.

9.2.3) Fish rearing conditions

Before juveniles reach one-half pound of fish per cubic foot of rearing space, they will be transferred into larger outdoor asphalt ponds and then to the large earthen reservoir on Battle Creek. Rearing densities will remain below one-half pound of fish per cubic foot of rearing space, and conditions will resemble natural habitat, as described in Sections 5.6 and 9.2.8.

9.2.4) Indicate biweekly or monthly fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available.

Relevant information pertinent to this question and growth data acquisition methods are being revised and assembled.

9.2.5) Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available.

Relevant information pertinent to this question and growth data acquisition methods are being revised and assembled.

9.2.5) Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Scretting Nutra Plus Starter Crumbles, sizes 0 and 1, will be fed to fry until they attain a mean weight of approximately 375 fish per pound (1.2 grams per fish). Feed conversion and efficiency ratios and data acquisition methods are under revision, but are not readily available at this time.

9.2.7) Fish health monitoring, disease treatment, and sanitation procedures.

Each year, NWIFC fish pathologists will screen a representative number of adults returning to the Bernie Kai-Kai Gobin Hatchery and associated rearing and release ponds for infectious fish pathogens that may be transmitted to the progeny. The exact number of fish that will be tested from each stock is specified in the Salmonid Disease Control Policy of the Fisheries Co-manager's of Washington State (NWIFC and WDFW 1998). Pathologists and an Enhancement Biologist will work with hatchery crews to help avoid pre-spawning mortality of brood fish to maximize fertilization, egg, and fish survival throughout the rearing cycle.

Preventative care will also be promoted through routine juvenile fish health monitoring. Pathologists conduct fish health exams at the Bernie Kai-Kai Gobin Hatchery and associated rearing and release ponds on a monthly basis from the time juveniles emerge until they are released. Monthly monitoring exams will include an evaluation of rearing conditions as well as lethal sampling of small numbers of juvenile fish to assess the health status of the population and to detect pathogens of concern.

Results will be reported to the Hatchery Manager and Enhancement Biologist along with any recommendations for improving or maintaining fish health. Vaccine produced by the TFHP may used when appropriate to prevent the onset of two bacterial diseases (vibriosis or enteric redmouth disease), although this has not proven to be necessary for any of the salmon stocks reared in the Tulalip enhancement program.

In the event of disease epizootics or elevated mortality in a stock, fish pathologists will be available to diagnose problems and provide treatment recommendations. Pathologists will work with the Hatchery Manager and personnel and the Enhancement Biologist to ensure that drugs and chemicals are used properly for disease treatments. The entire health history for each hatchery stock will continue to be maintained in a relational database called AquaDoc at the NWIFC Pathology Laboratory.

9.2.8) Smolt development indices (e.g. gill ATPase activity), if applicable.

Not currently available. However, gill Na+ - K+ ATPase, blood chloride, and sodium levels are currently under investigation.

9.2.8) Indicate the use of "natural" rearing methods as applied in the program.

All program fish will be transferred to Battle Creek pond, a natural earthen pond. They are held in this pond for a minimum of 21 days prior to release into Tulalip Bay. The characteristics of this pond closely mimic natural rearing conditions, including overhead cover, earthen substrate, natural feed supplementation, in-column structure, natural inflow, natural camouflage coloration/pond color, and presence of natural predators. Program fish will develop natural morphology and behavior, including more natural body coloration, predator avoidance and natural feeding behaviors, by adapting to these natural environmental conditions, which minimizes the influence of the artificial culture environment and is thought to increase their post-release survival.

9.2.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation.

Not applicable.

SECTION 10. RELEASE **Describe fish release levels, and release practices applied through the hatchery program.**

10.1) Proposed fish release levels.

Age Class	Maximum Number	Size (fpp)	Release Date	Location
Fingerling	8.0 million	375fish/lb.	April 15 - May 1	Tulalip Bay

10.2) Specific location(s) of proposed release(s).
Stream, river, or watercourse: Battle Creek (RM 0.3), Tulalip Bay.
Release point: Battle Creek.
Major watershed: WRIA 7 (Snohomish).
Basin or Region: Puget Sound.

10.3) Actual numbers and sizes of fish released by age class through the program.

See tulafachr.pdf and http://www.nwifc.wa.gov/CRAS.

10.4) Actual dates of release and description of release protocols.

See releases in Attachment 1. Release protocols and size at release were previously described in Sections 5.5, 9.15, and 9.17.

10.5) Fish transportation procedures, if applicable.

Tulalip Bay chum fry will be transferred from the Bernie Kai-Kai Gobin Hatchery to the Battle Creek final rearing and release pond. All fish will be transported in a hatchery fish transfer truck under oxygen and aeration in insulated tanks and released through a hose into the reservoir.

10.6) Acclimation procedures.

Acclimation procedures were previously described in Section 5.5. Most of the chum move out within a day after tail screens ar removed.

10.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.

All chum released from the Bernie Kai-Kai Gobin Hatchery will continue to originate from the Walcott Slough stock that was originally from Hood Canal that we marked genetically in brood years 1990 through 1993. We will continue to check this mark to see that it is strong enough to identify this stock for harvest management, broodstock selection, and straying evaluation purposes.

10.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels.

Not applicable, no surplus fish available at time of release.

10.9) Fish health certification procedures applied pre-release.

Fish health is monitored monthly by NWIFC fish pathologists to insure fish are healthy at release, as previously described in Sections 7.7, 7.9, 8.5, 9.1.7, and 9.2.7.

10.10) Emergency release procedures in response to flooding or water system failure.

We will always have the ability to alternate from well water, to west fork Tulalip Creek surface water, to east Fork Tulalip Creek surface water, or to move the fish to one of three reservoirs, in the event of power outages, well failure, or other catastrophic events that might somehow occur at the hatchery. Flooding has never been an issue at the hatchery or at the Battle Creek pond, but we could always release the fish into Battle Creek if some unforseen emergency prevented further rearing there, but this has ever occurred.

10.11) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases.

Given the perceived risks associated with hatchery programs (see Section 3.5), Tulalip enhancement program chum salmon will be reared and released in a manner to minimize potential negative impacts on listed Chinook salmon and bull trout populations. These measures will include:

- short-term rearing of these fish and their release directly into marine waters at 375 fish per pound is expected to lead to rapid emmigration away from local, nearshore areas.

- No listed species are present in freshwater areas where program fish are reared or released, and if they were, the release of program fish directly into marine waters eliminates potential interactions in the freshwater environment.

  Program fish may provide a source of forage for listed salmonids and other fishes.

SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

Note: Annual accomplishment of monitoring and evaluation of performance indicators is contingent on availability of funding. As of 2004, most research, monitoring, and evaluation projects have been accomplished primarily through acquiring Hatchery Reform and self-governance funds specifically dedicated for hatchery reform and rehabilitation.

Performance Indicator (Section 1.10)	**Monitoring Plan Objective** (Section 11)	**Methods/Comments** (Section 11)
On average, the estimated survival rate for hatchery production will remain above .005 to provide: • for the recruitment of at least 20,000 adult chum to Puget Sound annually, and • for sufficient adult chum passing through Area 8A to provide at least 4,000 fish for the Tulalip hatchery chum escapement each year.	Overall survival rate estimates will continue to be available from analysis of run reconstruction data as updated using genetic sampling information from Areas 8A and 8D.	▪ Run reconstructions will be reviewed, modified when appropriate, and analyzed to determine survival rates for the past 12 years. ▪ As funding allows, adult chum muscle tissue sampling will be continued in terminal area fisheries and electrophoretically analyzed to look for the Tulalip genetic mark. ▪ Age composition of adult chum caught in the terminal area fishery will be determined from scales collected in weekly sampling of the fishery catch.

Performance Indicator (Section 1.10)	**Monitoring Plan Objective** (Section 11)	**Methods/Comments** (Section 11)
▪ Annual fisheries plans will project exploitation rates below the co-managers' guidelines for all Puget Sound Chinook management units. ▪ Post-season assessments of exploitation rates on Stillaguamish and Snohomish Chinook will be below the co-managers' guidelines.	FRAM or successor model will be used to make annual projections of impacts.	Model inputs for incidental impacts from the Area 8D chum fishery on Chinook will be updated annually based on results of Chinook otolith sampling and analyses (see below for otolith sampling requirement).
▪ Annual chum spawning escapements will exceed co-managers' minimum escapement goals for both Stilliguamish and Snohomish management units. ▪ Post-season assessments of exploitation rates on Stillaguamish and Snohomish chum will remain below the co-managers' guidelines (50% maximum harvest rate on each management unit).	▪ Hatchery escapement will be reported annually as part of normal operations. ▪ Post-season assessment of chum exploitation rates will use run reconstruction data in combination with genetic sampling data.	▪ Accurate assessment of hatchery chum escapement will continue. ▪ As funding allows, muscle tissue samples from 200 chum per week in the Area 8A catch and 100 chum per week in the Area 8D catch will be collected and electrophoretically analyzed to look for the Tulalip genetic mark..

Performance Indicator (Section 1.10)	Monitoring Plan Objective (Section 11)	Methods/Comments (Section 11)
The proportion of Tulalip-origin chum spawners in the natural spawning areas will remain below the co-managers' guidelines.	The annual contribution of Tulalip hatchery chum to natural spawning populations will be estimated such that the upper bound of the 80% confidence interval will be 10% contribution when the true contribution rate is 5%.	▪ Tulalip chum have already been genetically marked (Rawson 1997; Attachment 2). ▪ Muscle tissues will be collected from at least 100 chum carcasses per year from key natural spawning populations in the Snohomish and Stillaguamish basins for genetic mark detection.
The level of interaction of hatchery fall chum bay releases with out-migrating natural salmonid smolts will be evaluated. The hypothesis that the timing of the peak abundance of Tulalip fall chum salmon and naturally-produced salmon in Tulalip Bay do not differ significantly, will be tested.	The abundance, and temporal and spatial distributions of the natural chum population in Tulalip Bay will be estimated. The timing of natural juvenile chum out-migration from local rivers will be estimated.	This will require a new research project to establish the optimum time/area strata for release that will minimize impacts on natural spawning populations.

SECTION 12. RESEARCH

12.1) Objective or purpose.

Please see the preceding Section 11 for M&E projects that are also research projects. 100% of the Tulalip Hatchery chum salmon production bear unique genetic marks (Rawson 1997; Attachment 2), which makes it possible to distinguish juvenile and adult hatchery and natural Tulalip chum stock components. This will enable evaluations of stray rates, hatchery and natural escapement estimates, and evaluations of ecological interactions between program chum and ESA-listed Chinook juveniles in the Snohomish estuary and nearshore marine areas. While the marking is automatic each year, funding for analysis of juvenile and adult samples will be required to accomplish studies of straying or ecological interactions of the hatchery production with other natural salmonids.

Annual accomplishment of research projects listed throughout this HGMP is contingent on availability of funding. As of 2004, most research and monitoring projects have been accomplished primarily through acquiring Hatchery Reform and BIA self-governance funds specifically dedicated for hatchery reform and rehabilitation.

1) Evaluate the contribution of Tulalip hatchery chum to terminal area fisheries and natural spawning populations. With adequate funding to run genetic tissue samples for allozyme analyses, additional adult monitoring will be implemented in the Snohomish basin to allow for enumeration of hatchery and natural stock components in the Snohomish coho escapement and for evaluations of straying.
2) Estuarine and nearshore marine occurrence timing, relative size overlap, and dietary composition of program chum and ESA-listed Chinook salmon juveniles. Very little is known about the relative contributions of natural- and hatchery-origin program chum and listed Chinook salmon juveniles and other salmonid juveniles to overall abundances, potential for competition, habitat capacities and utilization, temporal and spatial distributions in the Snohomish estuary and nearshore marine areas.

In addition to learning more about these important aspects of species viability, critical knowledge pertaining to life history diversity, such as behavior and ecological interactions are currently being obtained by these studies. Obtaining funding for genetic analysis of juvenile chum will enable identification of individual program fish in the estuary trapping efforts to allow for stomach content analysis and general observations of temporal and spatial co-occurrences with ESA-listed juvenile Chinook salmon to evaluate potential competition impacts and risks. These studies will provide valuable information to improve hatchery program effectiveness and aid salmon recovery in accordance with region-wide recovery plans and hatchery reform efforts.

12.2) Cooperating and funding agencies.

1) Past work has been funded by NOAA and with Pacific Salmon Treaty implementation funds passed through the NWIFC. Follow-up sampling was conducted from 2000-2002 with Pacific Salmon Treaty implementation funds, and these funds will be used to analyze these samples in 2003 or 2004.

2) The Tulalip Tribes and NOAA fisheries provide funding and cooperate to accomplish estuarine and nearshore marine trapping and seining, and evaluation of ecological interactions in the Snohomish basin. However, accomplishment of this proposed new monitoring project will require funding to run chum genetic samples and analyze stomach contents of Chinook and chum salmon juveniles to examine the potential for competition between these species.

12.3) Principal investigator or project supervisor and staff.

1) Principal Investigator: Kit Rawson. Project Supervisors: Kit Rawson, Mike Crewson, Richard Young, Tulalip Tribes.

2) Estuarine and nearshore marine environment habitat utilization and species composition studies: Mindy Rowse and Kurt Fresh (NOAA Fisheries), Brian Kelder, Kurt Nelson, Todd Zackey, Mike Crewson, Kit Rawson (Tulalip Environmental / Natural Resources Department).

12.4) Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2.

All natural chum stocks are healthy.

12.5) Techniques: include capture methods, drugs, samples collected, tags applied.

See Rawson (1997; Attachment 2), for details of genetic sampling.

12.6) Dates or time period in which research activity occurs.

See Rawson (1997; Attachment 2).

12.7) Care and maintenance of live fish or eggs, holding duration, transport methods.

Not applicable.

12.8) Expected type and effects of take and potential for injury or mortality.

None.

12.9) Level of take of listed fish: number or range of fish handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached "take table" (Table 1).

Negligible, see above.

12.10) Alternative methods to achieve project objectives.

None.

12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

Negligible mortality to any species is expected.

12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed fish as a result of the proposed research activities.

Samplers conducting foot surveys on the spawning grounds are trained to recognize and avoid redds and live fish. Fishery samples have no impact on listed fish. Estuarine and nearshore marine sampling is already covered under a different NOAA permit.

SECTION 13. ATTACHMENTS AND CITATIONS

CITATIONS

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ATTACHMENT 1.

RELEASED FRY-TO-ADULT SURVIVAL RATES, ADULT PRODUCTION LEVELS, AND ESCAPEMENT LEVELS. SURVIVAL ESTIMATES ARE BASED ON PUGET SOUND RUN RECONSTRUCTION WITH AGE PROPORTIONS DERIVED FROM SCALE-AGE ANALYSES.

Tulalip Hatchery Chum: Release and Return History.

Releases and survival rates.

Brood Year	Number Released	Pounds Released	Fish and Pounds	Return To ------- Adult Returns ------- Age 3	3 Age 4	(see note) Age 5	Total	Return/ Pound	Ret/100 Fish Released
1975	448,000	1,120	400.0	15	869	0	884	0.789	0.20
1976	1,808,300	3,875	466.7	1114	10534	481	12130	3.130	0.67
1977	1,840,200	4,606	399.5	6055	6358	43	12456	2.704	0.68
1978	414,800	967	429.0	802	1210	2584	4596	4.753	1.11
1979	11,200	22	509.1	40	1015	0	1055	47.969	9.42
1980	1,999,900	5,333	375.0	969	17041	86	18096	3.393	0.90
1981	1,280,000	3,450	371.0	5177	12066	2368	19611	5.684	1.53
1982	33,000	83	397.6	110	373	716	1199	14.448	3.63
1983	1,690,000	4,643	364.0	6365	3061	429	9855	2.123	0.58
1984	6,000,000	12,000	500.0	35978	94660	1526	132164	11.014	2.20
1985	2,500,000	6,250	400.0	12114	40329	2305	54748	8.760	2.19
1986	2,300,000	5,852	393.0	30810	27577	2959	61345	10.483	2.67
1987	5,300,000	15,143	350.0	11278	48901	736	60915	4.023	1.15
1988	5,800,000	14,872	390.0	10438	32106				
1989	5,800,000	19,333	300.0	11948					
1990	4,400,000	12,222	360.0						
1991	4,334,000	12,138	357.1						

NOTE: RETURN CODES: 0-ESCAPEMENT, 1-AREA 8D, 2-AREA 8A, 3-PUGET SOUND.
ODD BY AVG: 4.014 (RETURN/LB); 1.055 (RETURN/100 RELEASED)
EVEN BY AVG: 6.555 (RETURN/LB); 1.511 (RETURN/100 RELEASED)

ATTACHMENT 2.
MANAGEMENT APPLICATIONS OF THE GENETIC MASS-MARKING OF CHUM SALMON AT TULALIP HATCHERY

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Abstract

Chum salmon were sampled from terminal area fisheries and natural spawning areas to estimate the contribution of genetically-marked fish from Tulalip Hatchery. Weekly samples from two fishery areas showed variability in hatchery contribution between areas, among weeks, and among years. Weekly separation of hatchery and wild stocks in the fishery resulted in greatly different estimates of hatchery contribution than the annual stock separation method currently used. Adult in-river samples showed no evidence of hatchery fish straying to natural spawning areas throughout the two major river systems closest to Tulalip hatchery. However, samples of adult spawners and progeny fry in a small urbanized watershed near Tulalip Hatchery showed high levels of the Tulalip hatchery genetic mark.

Introduction

Using artificial selection of spawners, allele frequencies at two loci (mIDHP-1 and mMEP-2) were changed in chum salmon (Oncorhynchus keta) at Tulalip Hatchery, located on the Tulalip Indian Reservation in central Puget Sound, near Marysville, Washington. As a result of four years of this genetic marking, the allele frequencies at these two loci for this hatchery stock are now permanently changed and very different from the frequencies for the natural chum stocks in the region (Figure 1). I presented details of the genetic marking at the 1995 Pink and Chum Workshop (Rawson 1996). At that time I discussed potential applications of this mass mark to fishery management.

Since the last workshop, we have sampled chum salmon in terminal area fisheries and in natural spawning areas near Tulalip Bay and throughout the Stillaguamish and Snohomish river systems. We will use the results of electrophoretic analysis of these samples to improve the precision and accuracy of post-season reconstruction of the abundance of both hatchery and wild fish and to detect any straying of hatchery-produced fish into natural spawning areas. These analyses can then be used to modify both hatchery and harvest management procedures to provide full opportunity for the harvest of hatchery fish while maintaining appropriate harvest rates on wild fish. Here I report the initial results of this work.

The Tulalip Hatchery chum release and broodstocking facilities are located in Tulalip Bay, situated in north Puget Sound between the mouths of the Stillaguamish and Snohomish Rivers (Figure 2). Both of these rivers support several healthy stocks of fall-timed chum salmon (WDF et al. 1993). Tulalip hatchery fish are mixed with these wild stocks in Area 8A (Figure 2) where 100-200 thousand chum salmon are harvested per year by treaty Indian and non-Indian commercial fisheries. Although the Tulalip hatchery fish contribute significantly to the Area 8A fishery, the area is managed so that harvest rates will be appropriate to achieve the natural escapement goals to both river systems.

Currently, harvest management models are based on an assumption that the fraction of the Area 8A catch derived from hatchery fish is constant throughout the fishing year. However, the Tulalip hatchery run has a later timing than the Stillaguamish and Snohomish wild runs, which strongly suggests that the hatchery contribution to this fishery probably increases as the season progresses (Rawson 1996). This kind of deviation from the current assumptions can lead to significant differences in run reconstruction and other assessments of both the wild and hatchery stocks (Rawson 1996). One objective of the work reported here was to assess whether weekly stock separation of the Area 8A chum salmon catch using GSI would significantly change the estimated hatchery contribution to the fishery compared with the current annual run reconstruction method.

Tulalip Bay and nearby waters outside of Tulalip Bay are designated as Area 8D (Figure 2) and managed for the requirements of the Tulalip Hatchery fish. This management includes closing the area when protection is needed to allow returning adults to reach the broodstocking facility. At other times, Area 8D can be opened for the harvest of hatchery fish when Area 8A is closed to reduce harvest rates on wild fish. Annual combined treaty Indian and non-Indian chum harvest in Area 8D ranges from a few thousand up to 35 thousand fish. The current assumption for run reconstruction is that any catch in Area 8D is comprised entirely of Tulalip hatchery fish. Another objective of the current work was to evaluate this assumption through the chum management period.

Finally, the abundance of chum salmon produced by the Tulalip hatchery (as many as 100 thousand returning adults in some years) raises the question that some fraction of the hatchery-produced fish may be straying to natural spawning areas. The presence of a genetic mark in the hatchery fish enabled us to comprehensively sample throughout the natural spawning areas to see if, and to what extent, such straying may be occurring. Where we found evidence that the marked Tulalip hatchery fish might be contributing to the adult spawning population, we collected fry in the spring to determine the extent to which the hatchery-produced parents were contributing naturally-produced offspring to the system.

Methods

Results from chum salmon samples for the 1994, 1995, and 1996 return years are reported here. Weekly fishery samples were from Areas 8A and 8D and from the fishery in the Stillaguamish River conducted by the Stillaguamish Tribe. Hatchery rack samples were taken at the Tulalip Hatchery facility in Tulalip Bay and the Stillaguamish tribal hatchery in Harvey Creek, a tributary to the mainstem Stillaguamish River. Samples were also taken from fish on the spawning grounds at the principal known spawning locations throughout the Stillaguamish and Snohomish systems. Several locations in the Quilceda Creek system (Figure 2), which enters salt water in the Snohomish River estuary near Tulalip Bay, were also sampled. Table 1 lists the locations and samples taken by year. Sample numbers for natural spawning areas were generally 100 per location, except 200 for Quilceda Creek in 1996. The Stillaguamish in-river fishery and the Harvey Creek Hatchery had 200 samples taken per year. Area 8A was sampled at 200 fish per week, and Area 8D was sampled at 100 fish/week.

For the Area 8A fishery, samplers collected approximately 1 cm^3 each of heart, liver, and white muscle tissue from each fish sampled. These were washed, placed in test tubes, and immediately frozen on dry ice. All samples were stored at -80 °C until analysis at the Washington Department of Fish and Wildlife (WDFW) genetics laboratory in Olympia. Area 8A samples were assayed using starch-gel electrophoresis to assay for genetic variation at 29 loci. More detail on these methods can be found in the annual Puget Sound genetic stock identification reports (LeClair, et al. 1995). For the Tulalip Hatchery rack samples, we collected the above three tissues, plus eye tissue, for a full baseline analysis. However, the results for the hatchery return samples are not yet available.

Since the genotypes at the two Tulalip marker loci (mIDHP-1 and mMEP-2) can be assayed using only muscle tissue, this was the only tissue sampled from all locations other than the Area 8A fishery and the Tulalip hatchery broodstock. Muscle samples are collected from the ventral side of the caudal peduncle using a small stainless steel biopsy punch. In many of the natural spawning areas, adult chum salmon were caught with small gillnets and released alive after the muscle sample was taken in this manner.

Chum salmon fry were collected from several locations in Quilceda Creek (Figure 2), using electroshocking. One hundred fry per day were collected on six sampling occasions spread over the period April 5 - May 3, 1995. Fry were immediately placed on dry ice, and then stored at -80 °C. The WDFW genetics laboratory assayed these fish for allele frequencies at mIDHP-1 only.

I have done no quantitative analysis of raw data for this report other than to compute allele frequencies from genotypes. Most results are presented as graphs of gene frequencies for visual comparison with the baselines in Figure 1. I included some results from maximum likelihood estimation (MLE) of the 1994 area 8A samples reported by LeClair et al. (1995).

Results

Area 8A fishery samples from 1994 though 1996 showed variable allele frequencies from week to week, with the points graphing the frequencies at the two marker loci generally arrayed along a line between the North Sound and Tulalip Hatchery baselines (Figure 3). One week's sample (statistical week 47, 1995) was apparently nearly entirely comprised of marked Tulalip Hatchery fish, while one week (week 45, 1995) apparently was 100% North Sound natural fish. Earlier weeks (44-46) were generally closer to the North Sound and Hood Canal baseline frequencies, while later weeks (47-49) were closer to the Tulalip Hatchery baseline frequencies, with two exceptions.

MLE estimation of the Area 8A stock composition by week for 1994, as reported by LeClair et al. (1995), illustrates the degree to which run reconstruction can be improved by the use of weekly GSI estimates. Using the weekly Tulalip hatchery percent contribution to the Area 8A fishery times the weekly catch gives an estimate of 38,121 Tulalip Hatchery fish contributing to this fishery over the entire year (Table 2). In contrast, the current run reconstruction method which assumes equal contribution of all stock components over all weeks, estimates that only 13,000 Tulalip Hatchery fish contributed to the Area 8A fishery in 1994. Each of these Area 8A contribution estimates can be added to the extreme terminal run (Area 8D catch plus hatchery escapement) of 36,969 to obtain estimates of terminal run entering Area 8A. The weekly breakout method using GSI give a terminal run estimate of 75,090, while the annual run reconstruction method give a terminal run estimate of only 49,969.

The Area 8D fishery samples from 1995 and 1996 showed weekly and annual variation in allele frequencies at the marker loci (Figure 4). Five of the eight weekly samples were near the Tulalip Hatchery baseline, indicating that Tulalip Hatchery fish were predominant. The remaining three samples were intermediate between the Tulalip and North Sound baselines, indicating a mixture of hatchery and wild contributions.

The spawning ground and in-river samples from 1994-95 (Figure 5) and 1996 (Figure 6) showed similar, and clear, results. With the exception of the Quilceda Creek samples, all in-river samples were very close to the North Sound baseline frequencies at the Tulalip marker loci, indicating no straying of Tulalip fish to these locations throughout the Stillaguamish and Snohomish systems. In contrast, the allele frequencies in the Quilceda Creek samples are nearly identical with the Tulalip baseline frequencies at the marker loci, indicating a large or total contribution of Tulalip-origin fish to the natural spawning population of chum salmon in this system.

The frequencies of mIDHP*60 in all Quilceda Creek fry samples taken in 1995 were similar to each other and similar to the sample of the adult parent brood fish in the same area (Table 3). These seven gene frequencies are not statistically significantly different from each other (chi-square= .84, df=6; see formula in Fleiss, 1981, p. 139).

Discussion

Pella and Milner (1987) reviewed the use of naturally-occurring genetic marks as a tool for salmon management. GSI has subsequently been adopted as the principal method for chum salmon stock composition analysis in Washington and British Columbia. Through artificial selection of spawners in a hatchery population, the Tulalip Hatchery has created a permanent mass mark which extends the use of the GSI tool beyond general fishery stock composition analysis. GSI results we have obtained to date have allowed us to draw clear conclusions about the straying of hatchery fish into nearby natural populations and about week to week changes in the stock composition in terminal area fisheries.

The allele frequencies at the marker loci in the Area 8A and Area 8D fisheries show week to week and year to year variability. The comparison of the Area 8A weekly stock breakout with the current run reconstruction shows that the Tulalip Hatchery run may be underestimated by as much as 33% using current methods. Clearly, GSI should be incorporated into Puget Sound chum salmon run reconstruction if managers want accurate assessments of run strength. This type of detailed terminal area analysis should be incorporated into the Puget Sound-wide approach that Packer (1992) has already developed.

Because of the apparent high degree of annual variability in weekly stock composition estimates, it appears that it will be difficult to predict ahead of the time the week when, for example, Tulalip Hatchery fish will predominate in Area 8A. However, if managers wish to harvest the hatchery fish in that area at a higher rate than the wild fish, they could still effectively use the GSI tool and the Tulalip genetic mark. Weekly test fisheries could be sampled for muscle tissue only followed by overnight laboratory processing of the samples. Fishing rates could be increased on short notice when the test fishery samples began to show allele frequencies close to the Tulalip baseline. In this way, mass marking could be used to facilitate selective harvest of hatchery fish with non-selective net gear.

The Area 8D samples were predominantly, although not entirely, comprised of Tulalip Hatchery fish. Any errors in inappropriately assigning non-hatchery fish in Area 8D to the reconstructed Tulalip Hatchery run under the current run reconstruction method are exceeded by the error in not assigning a sufficient number of Area 8A fish to the Tulalip Hatchery stock. From the limited data available, weeks 45 and earlier have a lower contribution of hatchery fish in Area 8D than later weeks, so any closures to protect hatchery spawners would likely be ineffective before week 46.

The in-river samples clearly showed no evidence of straying of Tulalip Hatchery chum salmon into natural spawning areas throughout the Stillaguamish and Snohomish River systems. Several more years of comprehensive sampling will probably be required before this result can be definitively established.

The one exception to the pattern of no straying is Quilceda Creek, which enters the Snohomish estuary about five miles from the mouth of Tulalip Bay. This is a lowland stream whose watershed is largely in the urbanized area of the city of Marysville. Much of the Quilceda's channel has been artificially altered, straightened, and has become devoid of trees and shrubby cover. Often, spawning chum salmon are found in ditches behind trailer parks and housing developments. There is little evidence that this area ever supported a significant natural chum salmon population. Clearly, however, as shown by the 1995 fry data, adult chum from Tulalip hatchery are now successfully producing offspring in Quilceda Creek.

Although artificial genetic marking of salmon has been successfully accomplished before (e.g. L. Seeb et al. 1990), optimal methods of analyzing allele frequency data at just one or two marker loci have not been published. Current MLE stock composition methods require the use of many loci and multiple baseline or "learning" samples (Pella and Milner 1987). In looking at the data from this study, it was not clear to me that these methods could be directly applied to the questions I was asking. Perhaps new statistical methods will need to be developed for genetic mass- marking of hatchery salmon to achieve its full potential as a management tool.

Acknowledgments

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Table 1. Chum salmon samples in terminal area fisheries and spawning areas, 1994, 1995, and 1996. An "X" indicates that adult samples were taken. An "*" indicates that progeny fry samples were also taken.

Sample Location	Watershed	Type	1994	1995	1996
Area 8A		Fishery	X	X	X
Area 8D		Fishery		X	X
Tulalip Bay		Hatchery Rack	X*		X
Stillaguamish River	Stillaguamish	Fishery	X		
Harvey Creek	Stillaguamish	Hatchery Rack	X		X
Squire Creek	Stillaguamish	Spawning Ground			X
Jim Creek	Stillaguamish	Spawning Ground			X
Quilceda Creek	Snohomish	Spawning Ground	X*		X
Skykomish Slough	Snohomish	Spawning Ground		X	X
Schoolhouse Slough	Snohomish	Spawning Ground			X

Table 2. Breakout of Tulalip Hatchery fish from 1994 Area 8A chum salmon harvest using MLE analysis reported in LeClair, et al. (1995).

Statistical Week	Total Catch	Tulalip Hatchery Fraction[a]	Tulalip Hatchery Number	"Other" Number[b]
45	13,323	34%	4,530	8,793
46	7,520	29%	2,181	5,339
47	27,044	26%	7,031	20,013
48	30,717	49%	15,051	15,666
49	16,237	45%	7,307	8,930
>50[c]	4,491	45%	2,021	2,470
	99,332		38,121	61,211

[a]From LeClair, et al. (1995).

[b]Predominantly Stillaguamish and Snohomish-origin wild fish, but also includes "non-local" fish from other regions of origin.

[c]No Area 8A samples were taken after week 49. The Tulalip Hatchery contribution rate for weeks 50 and later is assumed to be the same as the rate estimated for week 49.

Table 3. MIDHP-1* allele frequencies for 1994 Quilceda Creek adults and 1995 Quilceda Creek fry.

Date		Sample Size	Frequency of *60 Allele	Frequency of *100 Allele
Fall 1994	Adult	113	.698	.302
5-6 April 1995	Fry	100	.722	.278
13 April 1995	Fry	100	.742	.258
19 April 1995	Fry	100	.725	.275
20 April 1995	Fry	100	.717	.283
26 April 1995	Fry	100	.741	.259
3 May 1995	Fry	100	.696	.304

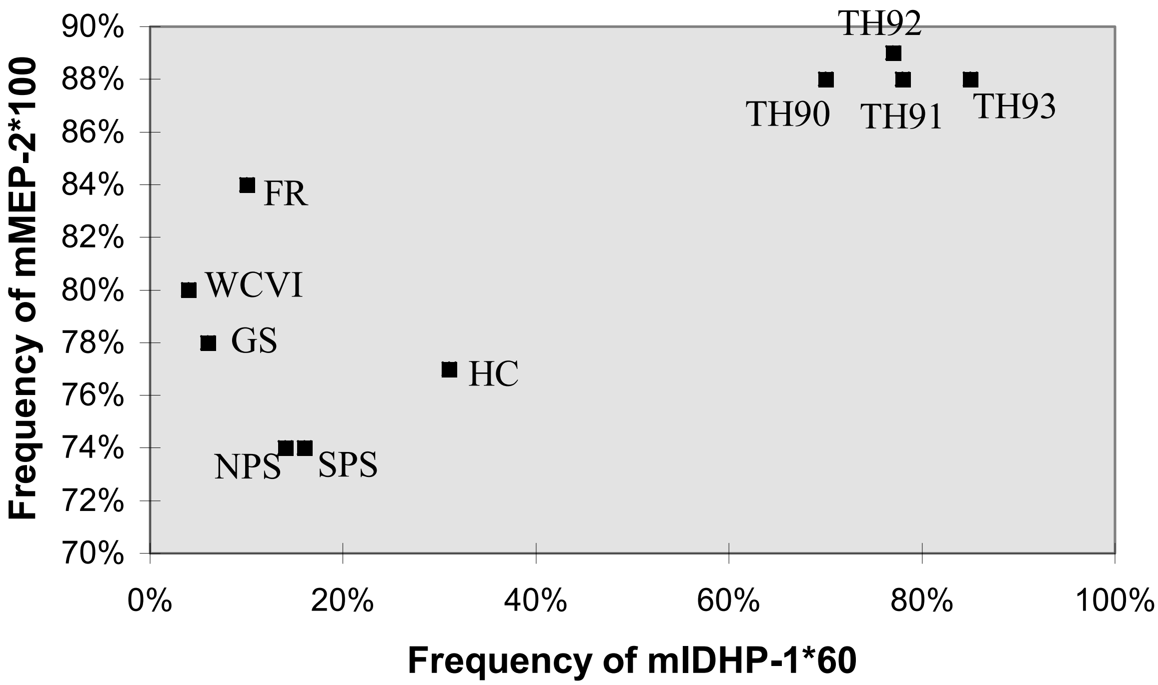

Figure 1. Allele frequencies at the two marker loci for natural chum salmon baselines (FR: Fraser River, WCVI: West Coast Vancouver Island, GS: Georgia Strait, NPS: North Puget Sound, SPS: South Puget Sound, HC: Hood Canal) and marked Tulalip Hatchery fish for brood years 1990 through 1993 (TH90, TH91, TH92, TH93).

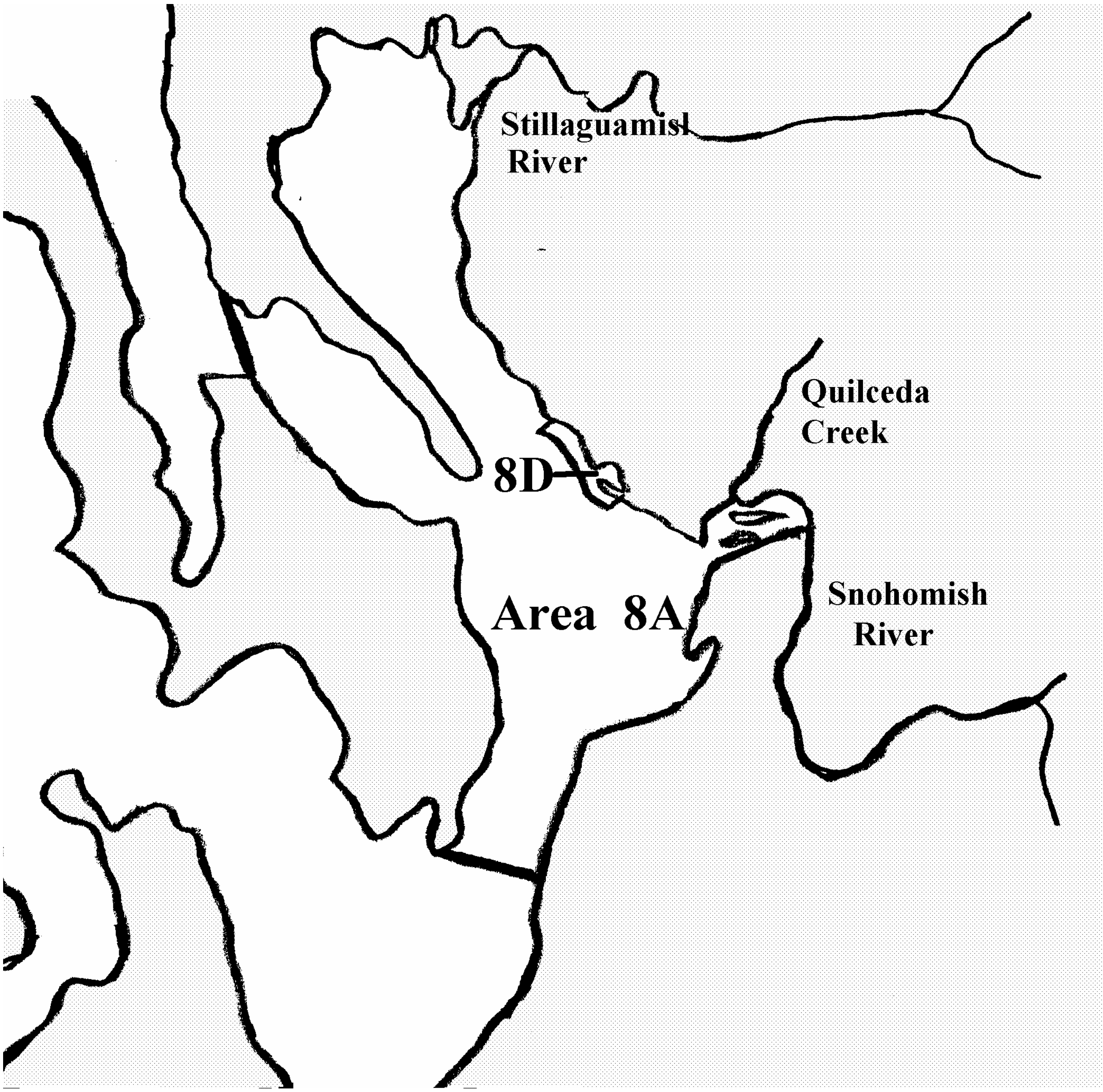

Figure 2. Map showing Tulalip Bay, the Stillaguamish and Snohomish Rivers, Quilceda Creek, Area 8A, and Area 8D.

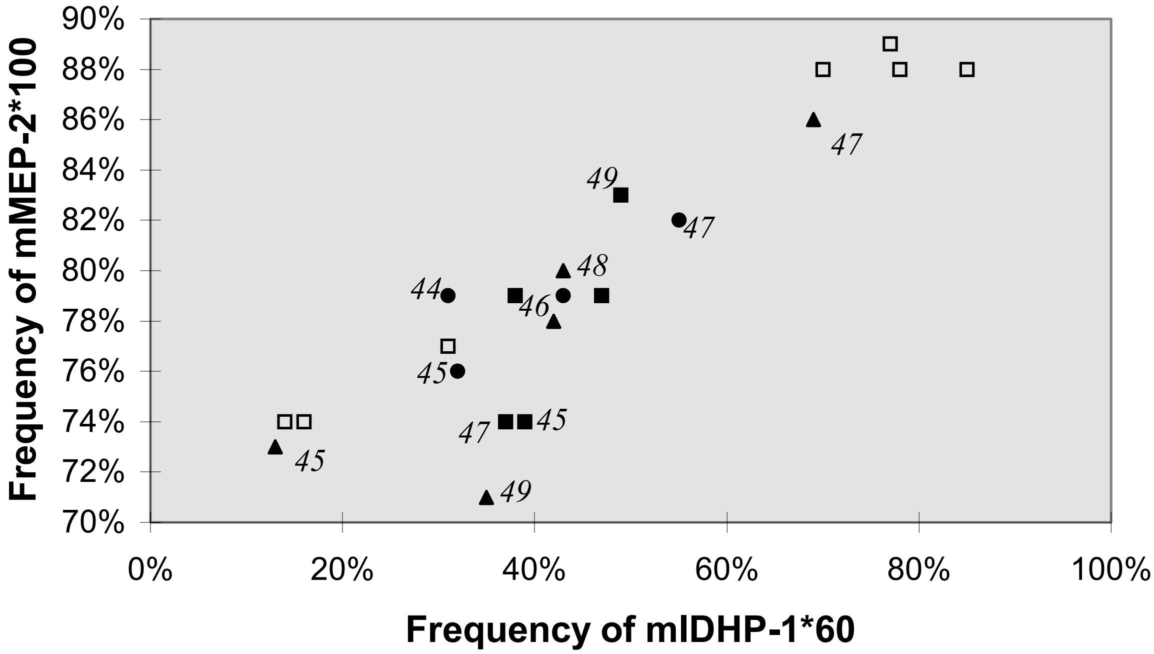

Figure 3. Allele frequencies at the marker loci for Area 8A fishery samples. Solid squares are 1994 samples, triangles are 1995 samples, and circles are 1996 samples. Points are labeled with statistical week number (week 45 is generally the first week of November). Open squares are baseline samples, see Figure 1.

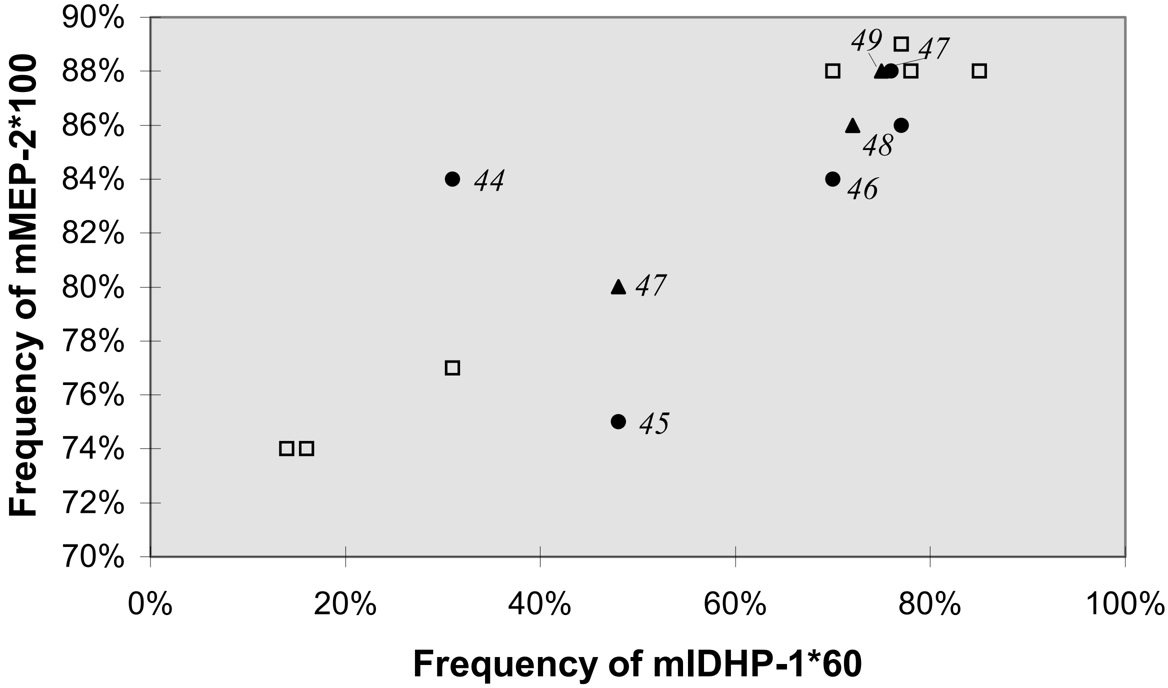

Figure 4. Allele frequencies at the marker loci for Area 8D fishery samples. Triangles are 1995 samples and circles are 1996 samples. Points are labeled with statistical week number (week 45 is generally the first week of November). Open squares are baseline samples, see Figure 1.

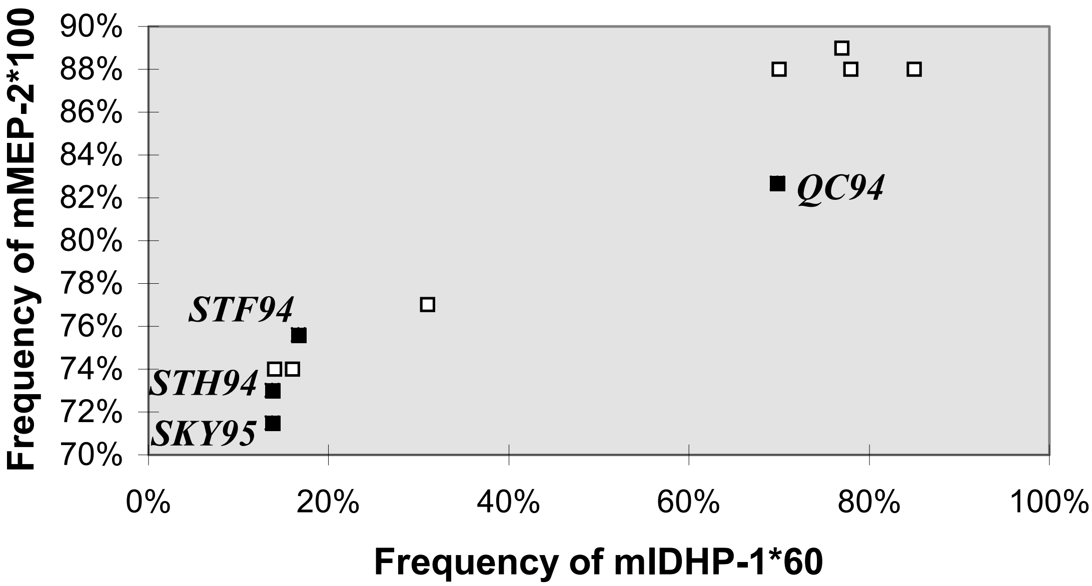

Figure 5. Allele frequencies at the marker loci for spawning grounds samples taken in 1994 and 1995 (QC94: Quilceda Creek, STF94: Stillaguamish in-river fishery, STH94: Stillaguamish Hatchery, Harvey Creek, SKY95: Skykomish Slough). Open squares are baseline frequencies, see Figure 1.

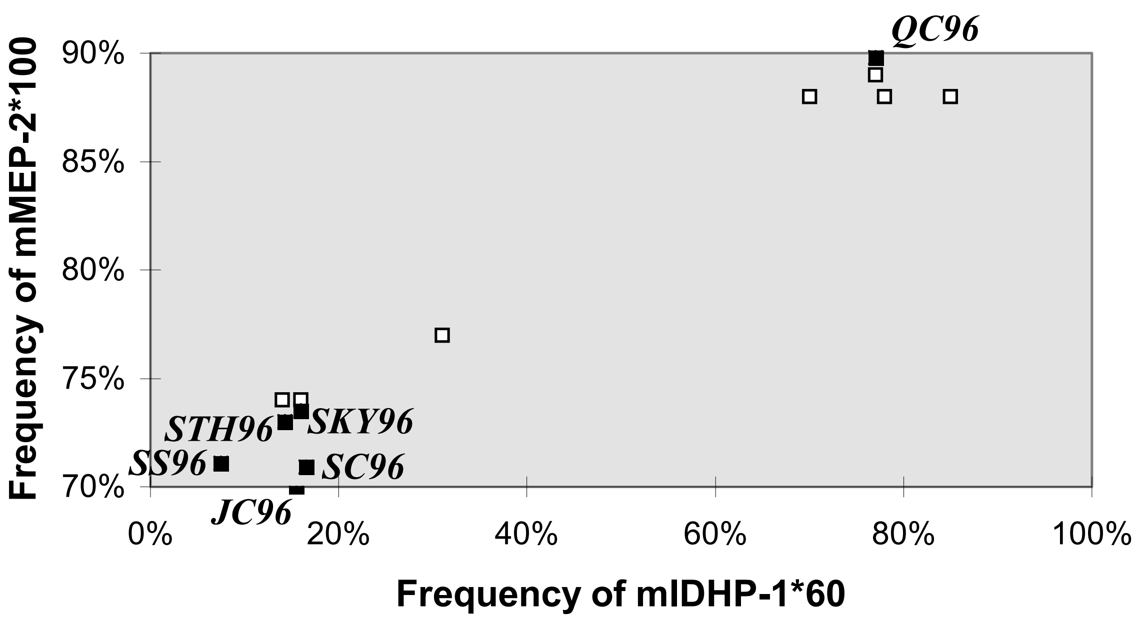

Figure 6. Allele frequencies at the marker loci for spawning grounds samples taken in 1996 (QC96: Quilceda Creek, STH96: Stillaguamish Hatchery, Harvey Creek, SKY96: JC96: Jim Creek, SC96: Squire Creek, Skykomish Slough, SS96 Schoolhouse Slough). Open squares are baseline frequencies, see Figur